Vagueness and successfull enough communication

Robert van Rooij
Joined with Michael Franke and Gerhard Jaeger

[1]University of Amsterdam

[2]University of Tübingen

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Overview

- Why is language vague?
- Strategic communication
- Why vagueness is not rational
- Reinforcement learning with limited memory
- Quantal Best Response

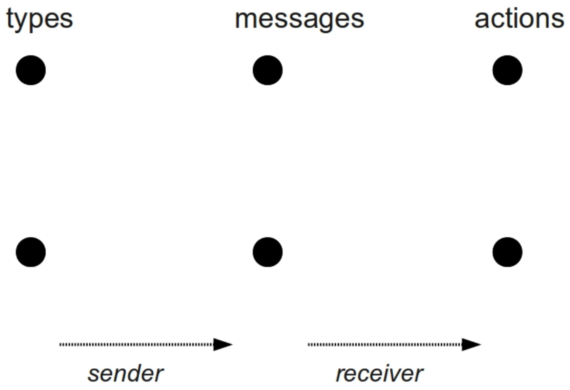
Why is language vague?

- Flexibility (common explanation): but only context dependence
- Facilitates search (van Deemter): but only preciseness
- Changing world
- Economists: non-identical preferences
- But want more.

Strategic communication: signaling games

- sequential game:
  1. **nature** chooses a type T
     - out of a pool of possible types T
     - according to a certain probability distribution P
  2. nature shows w to sender **S**
  3. S chooses a message m out of a set of possible signals M
  4. S transmits m to the receiver **R**
  5. R chooses an action a, based on the sent message.
- Both S and R have preferences regarding R's action, depending on w.
- S might also have preferences regarding the choice of m (to minimize signaling costs).

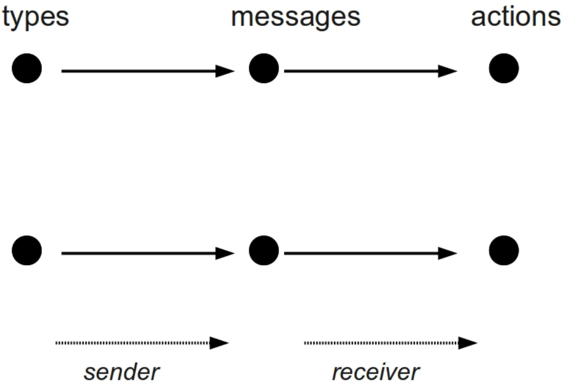
Basic example



utility matrix

	a_1	a_2
w_1	$1, 1$	$0, 0$
w_2	$0, 0$	$1, 1$

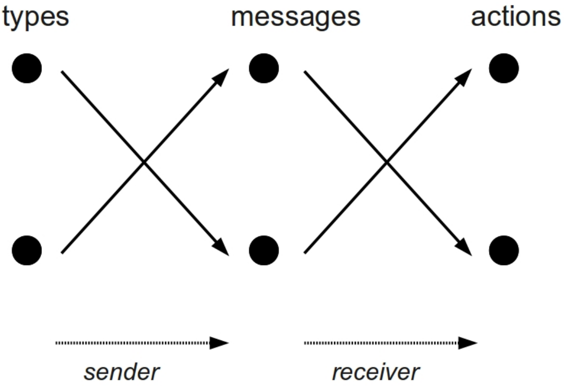
Basic example: Equilibrium 1



utility matrix

	a_1	a_2
w_1	$1, 1$	$0, 0$
w_2	$0, 0$	$1, 1$

Basic example: Equilibrium 2



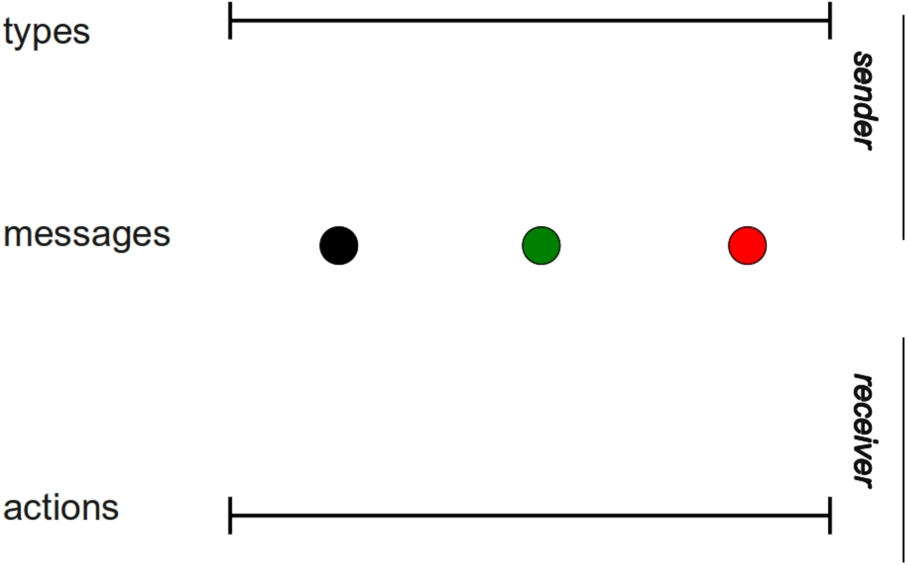
utility matrix

	a_1	a_2
w_1	$1,1$	$0,0$
w_2	$0,0$	$1,1$

Equilibria

- two strict Nash equilibria
- these are the only ‘reasonable’ equilibria:
  - they are evolutionarily stable (self-reinforcing under iteration)
  - they are Pareto optimal (cannot be outperformed)

Euclidean meaning space

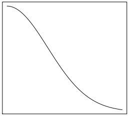


Utility function

General format

$$u_{s/r}(w, m, w') \quad = \quad \mathrm{sim}(w, w')$$

- $\mathrm{sim}(x, y)$ is strictly monotonically decreasing in Euclidean distance $\|x - y\|$



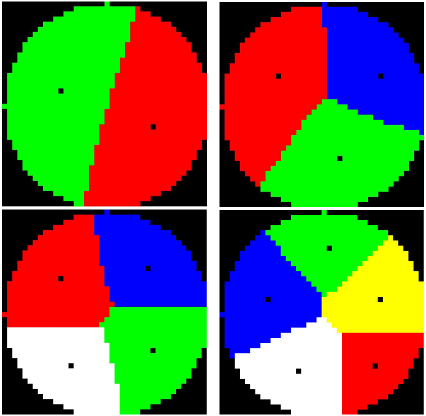
In this talk, we assume a **Gaussian** similarity function

$$\mathrm{sim}(x, y) \doteq \exp\left(-\frac{\|x - y\|^2}{2\sigma}\right).$$

Euclidean meaning space: equilibrium

Simulations

- two-dimensional circular meaning space
- finitely many pixels (meanings)
- uniform distribution over meanings



Vagueness

- many evolutionarily stable/Pareto optimal equilibria
- all are strict (except for a null set at category boundaries)
- a *vague* language would be one where the sender plays a mixed strategy

Vagueness is not rational

Rational players will never prefer a vague language over a precise one in a signaling game. (Lipman 2009)

- similar claim can be made with regard to evolutionary stability (as corollary to a more general theorem by Reinhard Selten)

Vagueness is not evolutionarily stable

In a signaling game, a vague language can never be evolutionarily stable.

Vagueness and bounded rationality

- Lipman's result depends on assumption of perfect rationality
- we present two deviations from perfect rationality that support vagueness:
  - Learning: players have to make decisions on basis of limited experience
  - Stochastic decision: players are imperfect/non-deterministic decision makers

Stochastic choice (Luce, 1965)

- real people are not perfect utility maximizers
- they make mistakes $\rightsquigarrow$ sub-optimal choices
- still, high utility choices are more likely than low-utility ones

Rational choice: best response

$$P(a_i) = \begin{cases} \frac{1}{|\arg_j \max u_i|} & \text{if } u_i = \max_j u_j \\ 0 & \text{else} \end{cases}$$

Stochastic choice: (logit) quantal response

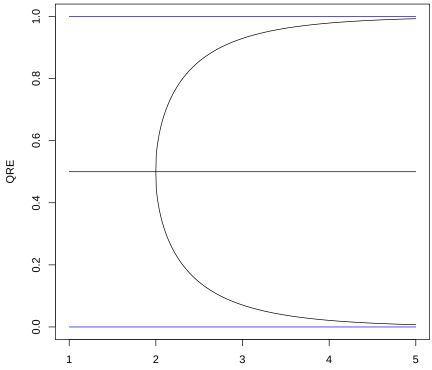
$$P(a_i) = \frac{\exp(\lambda u_i)}{\sum_j (\lambda \exp u_j)}$$

Quantal response

- λ measures degree of rationality
- $\lambda = 0$:
  - completely irrational behavior
  - all actions are equally likely, regardless of expected utility
- $\lambda \rightarrow \infty$
  - convergence towards behavior of rational choice
  - probability mass of sub-optimal actions converges to 0
- if everybody plays a quantal response (for fixed λ), play is in **quantal response equilibrium** (QRE)
- asl $\lambda \rightarrow \infty$, QREs converge towards Nash equilibria

Quantal Response Equilibrium of 2×2 signaling game

- for $\lambda \leq 2$: only babbling equilibrium
- for $\lambda > 2$: three (quantal response) equilibria:
  - babbling
  - two informative equilibria



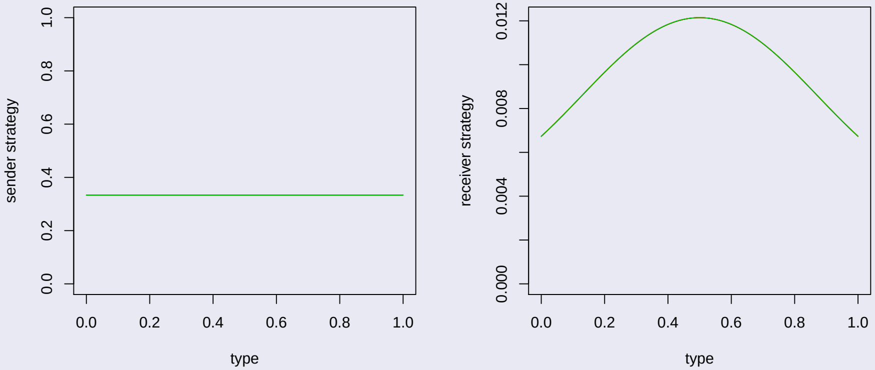
QRE and vagueness

- similarity game
- 500 possible worlds, evenly spaced in unit interval $[0, 1]$
- 3 distinct messages
- Gaussian utility function ($\sigma = 0.2$)

QRE and vagueness

$\lambda \leq 4$

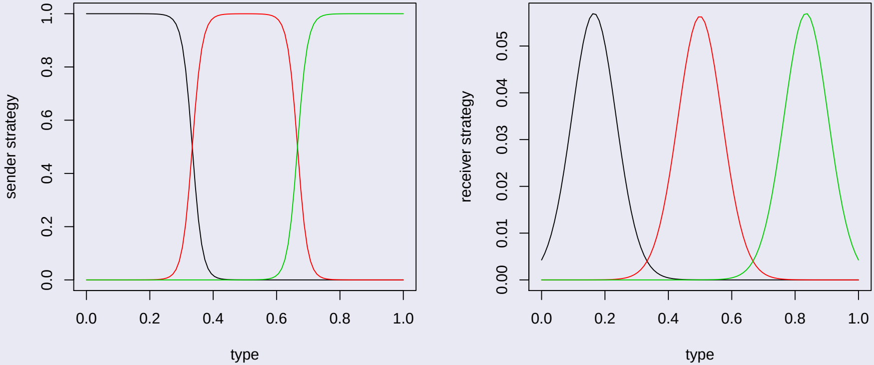
- only babbling equilibrium



QRE and vagueness

$\lambda > 4$

- separating equilibria
- smooth category boundaries
- prototype locations follow bell-shaped distribution



Meaning of λ

- Williamson: vagueness because we cannot observe precisely
  Don't **see** the world precisely
- Graff: vagueness because we don't know our preferences
- All of this, and more, is compatible with a non-perfect λ
- All of this is even explicitly discussed by Luce (1965)
- Notice: higher-order vagueness follows immediately from this picture

From Language to Thought

- We don't have to think of signaling as a 2-person game:
  One person observing, representing, and acting of/on world is enough
- Given our non-perfect λ, this suggest that our thoughts/beliefs are vague as well
- $\Rightarrow$ it is not that we have precise thoughts that we only vaguely communicate
  but we have only vague thoughts that we want to communicate in language
- $\Rightarrow$ it is irrational to make our language precise
- That's why language is and should be vague!